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Published in:
Geophysical Research Abstracts

Published: 01/04/2016

Document Version
Publisher's PDF, also known as Version of record

Link to publication on the UWS Academic Portal

Citation for published version (APA):
Zihms, S., Lewis, H., Couples, G., Hall, S., & Somerville, J. (2016). Comparison of deformation mechanics for two different carbonates: oolitic limestone and laminites. *Geophysical Research Abstracts*, *18*, [EGU2016-173].

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Download date: 05 May 2023

Geophysical Research Abstracts
Vol. 18, EGU2016-173, 2016
EGU General Assembly 2016
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Comparison of deformation mechanics for two different carbonates: oolitic limestone and laminites

Stephanie Zihms (1), Helen Lewis (1), Gary Couples (1), Stephen Hall (2), and Jim Somerville (1)

(1) Heriot Watt University, Institute of Petroleum Engineering, Edinburgh, United Kingdom (stephanie.zihms@pet.hw.ac.uk), (2) Lund University, Division of Soild Mechanics, Lund, Sweden

Carbonate rocks form under a range of conditions which leads to a diverse rock group. Even though carbonates are overall mineralogically simple, the solid-space distribution ranges from simple compositions such as oolitic limestones to highly complex networks of pores and solids as seen in coquinas. Their fundamental mechanical behaviour has been identified to be like clastic rocks (Vajdova 2004, Brantut, Heap et al. 2014). However it is very likely that this observation is not true for more complex carbonates. Triaxial tests were performed on cylindrical samples of two different carbonates; a) oolitic limestone (Bicqueley quarry, France) and b) laminite (Aripe basin, Brazil). The samples were deformed under confining pressures of 8, 12 and 20MPa, and 20, 30 and 40MPa, respectively. All tests were stopped as soon as peak load was observed to preserve as many deformation characteristics as possible. Photographs of the samples were taken before and after deformation to allow surface analysis of deformation features. Additionally, samples were analysed post-deformation with X-ray tomography (XRT) (using the Zeiss XRadia XRM 520 at the 4D Imaging Lab at Lund University). The 3D tomography images represent the post-deformation samples' density distribution, allowing detailed, non-destructive, 3D analysis of the deformation features that developed in the triaxial testing, including the complex geometries and interactions of fractures, deformation bands and sedimentary layering. They also provide an insight into the complexity of deformation features produced due to the carbonate response.

Initial results show that the oolitic limestone forms single shear bands almost the length of the sample, exhibiting similar characteristics to sandstones deformed under similar conditions. These features are observed for all three applied loads. The laminate sample deformed at the lowest confining pressure exhibits compactive features. However, the laminite samples deformed at the two higher confining pressures both show highly complex fracture networks comprising open fractures and fracture propagation. This suggests that the laminate changes from compactive to dilational responses over the selected confining conditions. The XRT analysis indicates that a more complex fracture distribution could be linked to rock component properties e.g. grain size and composition. For the laminite these are variable with the layers. This is in agreement with field observations of laminite microfabrics (Calvo, Rodriguez-Pascua et al. 1998). Additionally, the typical grain size of the laminate (μm) is much smaller than the oolitic limestone (mm), which suggests that fracture network complexity can also be linked to bulk system complexity i.e. pore & grain network.

These deformation experiments show that, as previously observed, oolitic limestones seem to behave similarly to sandstones. However this observation is not true for laminites and it is very likely that more complex carbonates will develop even more complicated deformation behaviour. It is therefore necessary to systematically test different carbonate rocks to understand the impact of geometry and composition, as well as the interplay with the pore network.

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